



Transforming Rural Environmental Governance in China: Linking Farmers' Participation, Policy Mechanisms, and Infrastructure Conditions

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Abstract

This study focuses on farmers' willingness to participate in the source separation and reduction of rural household waste, aiming to resolve the dilemma of "government enthusiasm versus farmers' apathy" in rural household waste governance, promote the transformation of the governance model from administrative dominance to endogenous drive, and provide a reference for the modernization of rural environmental governance. By analyzing the current situation of rural household waste generation and treatment, the characteristics of farmers' participation, the policy environment, and infrastructure, this study identifies key governance issues and reveals the core factors affecting farmers' willingness and behavior to participate through empirical data. The results show that: (1) There is a significant inconsistency between rural households' willingness and behavior in waste sorting. 72% of rural households explicitly express their willingness to participate, but the actual implementation rate is only 31%, which is affected by differences in individual knowledge, income, and age. (2) The implementation of policies lacks interdisciplinary theoretical integration. The proportion of flexible expressions in national-level policies is 63%, while the proportion of rigid clauses in local rules rises to 47%. (3) There are obvious deficiencies in infrastructure and technology, with uneven regional coverage. The error rate of manual garbage data statistics reaches 23%, leading to data fragmentation and resource waste. This study provides targeted paths for improving farmers' participation in waste sorting and optimizing rural environmental governance strategies. It emphasizes the need to consider the heterogeneous characteristics of farmers, balance policy flexibility

and technical adaptability, and build a multi-stakeholder collaborative governance system.

Subject Areas

Environment

Keywords

Rural Household Waste, Source Separation and Reduction, Willingness to Participate

1. Introduction

With the continuous promotion of the rural revitalisation strategy, the economic and social development of rural areas has entered a new stage, and residents' lifestyles have accelerated the transition to urbanisation, which at the same time has brought about an increase in the amount of rural living rubbish generated. Data show that the amount of rural waste disposal in China rose from 340 million tonnes to 570 million tonnes during the period of 2018-2024, and the surge in waste production has brought unprecedented pressure on the rural ecological environment. There has been a significant structural change in the composition of rubbish, with the share of plastic household waste rising sharply from 28% in 2015 to 41% in 2024, while the share of conventional organic waste has declined from 65% to 52%. This trend of compositional diversification makes it difficult to cope with the model originally applied to single organic waste treatment, and the difficulty of treatment has increased exponentially.

Currently, rural household waste management is facing multiple serious challenges. In terms of treatment, 70% of rural household waste is still treated in the crude mode of mixed collection and simple landfill, which is not only inefficient but also poses a serious threat to the ecological environment. Surface water eutrophication caused by waste leachate is becoming more and more prominent, and has become an important source of water pollution in rural areas, while the accumulation of rubbish breeds germs and odours, which have gradually evolved into a major hidden danger for rural public health and safety. From the perspective of regional governance, rural household waste management shows a significant gradient difference, which is closely related to the level of economic development, forming a distinct pattern of "strong in the east and weak in the west". With a strong economic foundation, the eastern coastal areas have built a more complete waste management system, while some poor counties in the central and western regions are limited by capital investment and technical support, and the resource utilisation rate is low. This not only restricts the overall improvement of rural habitat, but also becomes a prominent contradiction that hinders the sustainable development of the countryside. From the perspective of the participation dimension of farmers, the willingness to participate deviates from the actual be-

haviour. Survey data show that 72% of farmers clearly expressed their willingness to participate in rubbish classification, but the actual implementation rate is only 31%, behind this “high willingness, low implementation”, reflecting the deep contradiction in the governance system. In addition, the willingness of farmers to participate also shows obvious individual heterogeneity, divided in the three dimensions of knowledge, income and age, with the willingness of young farmers aged 18 - 30 with college education and above, annual household income of more than 100,000 yuan, significantly higher than that of the uneducated, with annual household income of less than 50,000 yuan, and the elderly group aged 60 or above, which further exacerbates the difficulty of governance due to the differences in the generations and strata. There are also obvious shortcomings in policy implementation and governance models. Although the national government has issued a policy to achieve a 60% coverage rate for rural household waste separation by 2025, there is a tendency towards rigidity in the implementation of the policy. National-level policies to encourage guidance and other flexible expressions accounted for 63%, while local rules must be prohibited and other rigid provisions accounted for 47%, administratively driven campaign governance leads to a mismatch of resources, the formation of high input, low efficiency.

It is in this context, how to crack the governance dilemma of “government hot, farmers cold”, stimulate the endogenous motivation of farmers to participate in the classification and reduction of rural household waste at source, and promote the governance model from administrative dominance to multi-dimensional synergies, which has become a realistic proposition that must be overcome to achieve the modernisation of rural environmental governance. This study focuses on the core variable of farmers’ willingness to participate, systematically analyses the current situation and puts forward countermeasures, with a view to providing theoretical and practical paths for solving the problems of rural household waste management.

2. Materials and Methods

The sampling frame covered rural households across multiple regions in China aiming to ensure the diversity and representativeness of the sample. The survey was conducted from February 5 to February 15, 2024, using a combination of online and offline methods. Online questionnaires were distributed via the Wenjuanxing platform. The survey covered rural areas in eastern, central, and western China, including provinces such as Hebei, Shandong, Henan, Sichuan, and Gansu, to ensure the sample’s representativeness across different economic and geographical regions. A total of 683 questionnaires were collected and after excluding invalid ones, 442 valid responses were obtained, resulting in an effective response rate of 64.7%.

The questionnaire consisted of three parts: an introduction to the survey background and purpose, collection of demographic information and items measuring variables related to farmers’ willingness to participate in rural domestic waste source classification and reduction. The variables were measured using a 5-point Likert scale including 7 latent variables and 1 endogenous latent variable with 28

observed items in total.

3. Current Situation Analysis of Farmers' Willingness to Participate in Source Separation of Rural Household Waste

3.1. Analysis of the Current Situation of Rubbish Generation and Disposal

The amount of rubbish disposal continues to grow. With the in-depth promotion of the rural revitalization strategy, the transformation of rural residents' lifestyles to urbanisation is accelerating, and the amount of living rubbish generated is showing rigid growth. The statistics of China's rural rubbish disposal volume from 2018 to 2024 show that the disposal volume in 2018 was 340 million tonnes, and it has risen to 570 million tonnes in 2024, and the proportion of plastic daily-use waste has increased from 28% in 2015 to 41%, while the share of conventional organic waste declined from 65% to 52% [1]. This structural change makes rural household waste treatment significantly more difficult, and the mixed collection and treatment model is difficult to adapt to the reality of diversified waste components. **Figure 1** presents data on China's rural waste disposal volume from 2018 to 2024, which shows a clear upward trend, reflecting the current growing pressure on China's rural household waste production [2]. How to break through the governance dilemma of "government hot, farmers cold" has become a realistic proposition that needs to be solved urgently to achieve the modernisation of rural environmental governance [3].

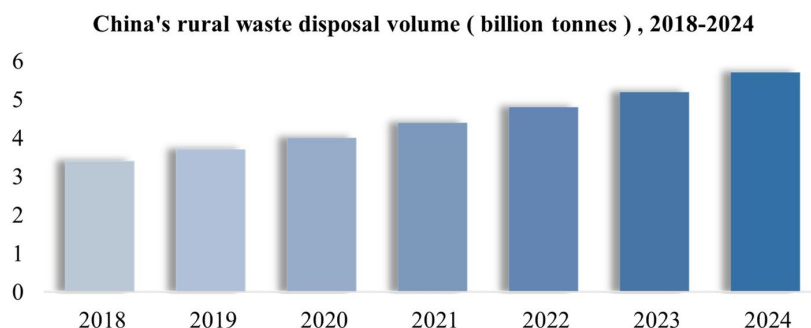


Figure 1. Waste disposal volume in rural areas of China.

Rough treatment method. At present, 70% of rural household waste is still treated by mixed collection and simple landfill, and this kind of rough treatment threatens the ecological environment [4]. Water pollution manifests itself in the eutrophication of surface water bodies caused by rubbish leachate, and rubbish pollution has become an important hidden danger to rural public health safety [5].

Regional governance level is not balanced. Rural living rubbish governance presents obvious regional gradient differences, China's rural habitat environment continues to improve, but the rural living rubbish problem has increasingly become an outstanding contradiction that restricts sustainable development [6]. The

eastern coastal areas have built a more complete system, achieving a classification participation rate of 82% for farm households and a resource utilisation rate of 65%. While the governance capacity of the central and western regions is obviously lagging behind, reflecting the constraining effect of the level of economic development on environmental governance, and the input gap leads to a significant differentiation of governance effectiveness [7].

3.2. Analysis of the Current Situation of Farmers' Participation

Implementation rate refers to the proportion of farmers who actually put into practice the relevant requirements such as garbage classification in rural domestic waste management actions, which is used to measure the actual effect of policy implementation. Individual heterogeneity characteristics of participation willingness. Farmers' willingness to participate presents obvious characteristics of three-dimensional differentiation in knowledge, income and age. In terms of education, the intensity of the classification willingness of farmers with college education and above is higher, significantly higher than that of uneducated farmers. Farmers with annual household income of more than 100,000 yuan have a stronger willingness to classify, significantly higher than those with less than 50,000 yuan. Age differences are even more prominent, with the willingness of young farmers between the ages of 18 and 30 years old and the older group over 60 years old, forming a clear intergenerational participation divide. Behind this heterogeneity is the dual role of cognitive ability and life habits, the current status of farmers' participation is shown in **Table 1**.

Willingness to participate refers to the subjective thoughts, motivations and desires of villagers regarding their involvement in activities related to rural domestic waste management, and it is the initial psychological factor for the occurrence of participation behavior. Willingness to participate behaviour and low implementation paradox. Although 72% of the farmers expressed their willingness to participate in sorting, the actual implementation rate of sorting behaviour was only 31% (The data is derived from the household questionnaire survey conducted by this study from February 5 to February 15, 2024, through a combination of online and offline methods, with an effective sample size of 442), forming a significant willingness-behaviour paradox. In-depth analysis showed that accessibility of facilities was the key constraint, and the actual implementation rate was only 18% in villages with less than 40% coverage of sorting bins, while the implementation rate increased to 53% in villages with 80% coverage [8].

Table 1. Current status of farmers' participation.

Dimension	Group division	Participation Willingness Strength Characteristics
Education level	College degree or above (49.1%)	25% higher than the uneducated group
	Uneducated (7.7%)	25% lower than the group with tertiary education and above

Continued

Household Income	Above 100,000 RMB	Affirmative responses accounted for 65% of the total
	Below \$50,000	Only 35% of positive responses
Age	Young farmers aged 18-30 (44.3%)	The proportion of those who actively signed up to participate in the sorting and guidance activities was 57%
	Elderly group over 60 years old (9.3%)	The proportion of active registrations to participate in classification guidance activities are 19%

3.3. Analysis of the Current Situation of the Policy Environment

Rigid policy provisions refer to the regulations within rural domestic waste management policies that have clear and strict requirements and do not allow for easy changes. Flexible policy provisions refer to the policy contents that, within a certain principle framework, can be appropriately adjusted and adapted according to the actual situations of different villages, the characteristics of farmers, and so on. Hierarchical construction of the policy system. Top-level design policies have been formed at the national level, and the Five-Year Action Programme for Improving and Upgrading the Rural Habitat Environment specifies the target of 60% coverage of rural household waste classification by 2025. The Action Programme for Combating Pollution in Agricultural and Rural Areas has refined the standards for the construction of classification facilities, and provinces and municipalities have formulated implementation details in the light of actual practice. This hierarchical policy design reflects the governance idea of central coordination and local innovation, but the analysis of the policy text shows that 63% of the national level documents encourage guidance and other flexible expressions, while the local fine must be prohibited and other rigid provisions accounted for 47%, reflecting the tendency of rigidity in the implementation of the policy. How to break through the governance dilemma of “government hot, farmers cold” has become a realistic proposition that needs to be solved urgently to achieve the modernisation of rural environmental governance. The current situation of the policy environment is shown in **Figure 2**. The government has invested heavily in the construction of facilities, but the active participation rate of farmers is less than 30%. Administrative promotion is mainly manifested as campaign-style governance, which is easy to lead to the phenomenon of policy suspension, and the mismatch of governance resources makes the policy’s effect, forming a governance circle of high input and low efficiency.

The double effect of environmental regulation is revealed. Structural equation modelling reveals the negative moderating effect of environmental regulation, i.e., high-intensity administrative intervention will weaken the efficiency of the transformation of behavioural attitudes into willingness to participate. A more far-reaching effect is the suppression of endogenous motivation. In villages relying on administrative promotion, the sustainability of the classification behaviour of farmers is only 14 months, while in villages where endogenous motivation is cul-

tivated through community building, the sustainability reaches 32 months, reflecting the short-term effect and long-term limitation of the means of regulation.

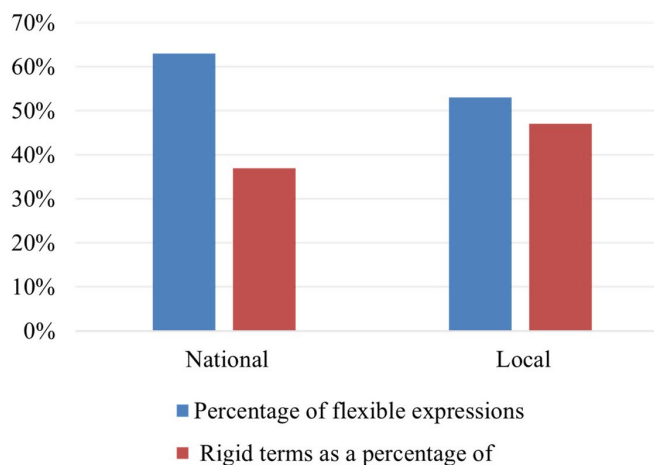


Figure 2. Current situation of the policy environment.

3.4. Analysis of Infrastructure

Inadequate coverage and lagging maintenance of classified facilities, with significant regional differences. Some villages in the eastern coastal areas are equipped with waste separation bins for each household, while only 12% of villages in poor counties in the central and western regions have waste separation bins, and in mountainous areas, the waste retention rate is over 40% due to the narrow roads and the difficulty of accessing large transfer trucks. Most villages rely on village cadres to maintain facilities on a part-time basis, and the average professional maintenance response time is 7.2 days, much higher than the 2.1 days in cities.

Urban intelligent identification technology has an accuracy rate of only 58% in rural areas due to the complexity of waste composition. The aerobic composting cycle in the North is 1.8 times higher than that in the South. Rural areas still manually count rubbish data, with an error rate of 23%, and sectoral data fragmentation, the lack of real-time monitoring and intelligent decision-making platforms, resulting in poor transport connections, waste of resources and other problems, the current state of infrastructure is shown in **Table 2**.

Table 2. Status of Infrastructure.

Type of problem	Specific Indicators	Data details
Poor technology adaptability	Urban smart identification accuracy rate	Rural only 58%
	Aerobic composting cycle North-South comparison	1.8 times higher in the North than in the South
Lack of digital management	Error rate of manual statistics	23%
	Status of management platform	No real-time monitoring and intelligent decision-making platform, data fragmentation

4. Problems Analysis of Farmers' Willingness to Participate in Source Separation of Rural Household Waste

4.1. Imbalance in Rubbish Generation and Treatment, Poor Technology Adaptation

There are multiple structural contradictions in the generation of rural household waste, as shown in **Figure 3** below. It is centred on four problems: increasing quantity, changing quality, low efficiency and imbalance, which seriously restrict the effectiveness of source separation and reduction.

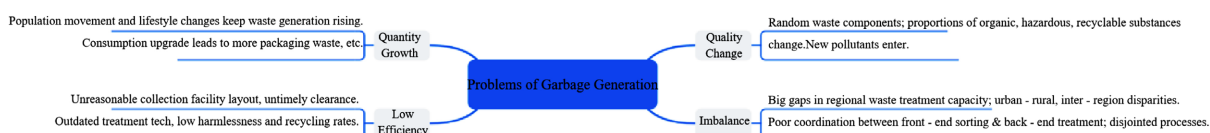


Figure 3. Problems of garbage generation.

Rigid growth in the amount of rubbish generated and structural variations in the composition of rubbish have created a crisis in the suitability of treatment capacity. Between 2018 and 2024, the amount of rural rubbish to be treated will rise from 340 million tonnes to 570 million tonnes, with a compound annual growth rate of 8.7%, and the diversification of the rubbish composition has highlighted the difficulty in treating the rubbish. This structural change has transformed rural waste from a single component of predominantly perishable organic waste to a mixture of complex components such as plastics, paper, and food waste. However, the existing treatment system still continues the simple model for traditional organic waste, resulting in plastics and other difficult-to-biodegrade waste being mixed into the treatment process, reducing the efficiency of resourcing, and creating the risk of secondary pollution. The gradient imbalance of regional governance capacity exacerbates the pollution depression effect. Restricted by the level of economic development, rural waste management presents a significant pattern of strong east and weak West, the eastern coastal areas have built a complete system of classification collection, special transport, resource treatment, the participation rate of classification of agricultural households reached 82%, the resource utilisation rate of 65%; while the poor counties in the central and western part of the country are equipped with classified bins in only 12% of the villages, and the resource utilisation rate is less than 8%, and the waste retention rate is more than 10% in some mountainous areas due to the narrow roads and the difficulty of access to large transfer vehicles. In some mountainous areas, due to narrow roads and difficulties in accessing large transfer trucks, the rubbish retention rate exceeds 40%, creating a passive situation in which rubbish is generated and then piled up. This regional imbalance has not only led to a continuous increase in ecological pressure on rural areas in the central and western regions, but has also led to regional environmental conflicts and weakened the overall effectiveness of governance due to the transfer of rubbish across regions.

Rough treatment and the accumulation of ecological risks have created a shortcoming in governance. 70% of rural household waste is still collected in a primitive way, with simple landfills, which lack basic seepage control and leachate treatment facilities, leading to two prominent problems: firstly, the leachate from the waste seeps directly into the soil and surface water, triggering eutrophication of the water body, and becoming the primary source of water pollution in rural areas. Secondly, the accumulation of mixed waste breeds germs, making the area around the landfill a public health and safety hazardous area, directly threatening the health of farmers. In addition, there is a disconnect between the urban application of treatment technologies and the actual needs of rural areas. Because of the complexity of rural waste, the accuracy rate of the intelligent identification and classification technology promoted in cities is only 58%, far lower than the 89% rate in cities. The lack of technological adaptability has led to the paradox of advanced technology being idle and traditional methods being inefficient, further widening the gap between the amount of waste generated and the treatment capacity.

4.2. Low Participation Execution of Farmers

The direct effect of behavioural attitudes on the willingness to participate is not significant, reflecting the complex blocking mechanism of attitude transformation. At the cognitive level, the perception of environmental protection exaltation leads to attitudinal deflation, and farmers regard sorting as a noble act required by the government rather than a self-interested daily habit, which makes attitudes lack behavioural driving force [9]. At the environmental level, the vicious circle of facilities and attitudes is formed, and this multiple blockage makes it difficult to transform attitudes into actual willingness, forming the paradoxical state of cognitively agreeing and delaying actions [10]. The transformation dilemma of the rural social norms system is the failure of norms brought about by the structural change of the rural society. With the exodus of young adults, the hollowing out of the countryside has led to the transformation of the society of acquaintances to a society of semi acquaintances, and this weakening of social ties has led to the diminishing role of others' evaluation as a constraint on behaviour [11]. The failure of subjective norms causes farmers' sorting behaviour to lack group pressure support.

Farmers' low perception of the feasibility of classification. In terms of knowledge and skills, the classification knowledge divide is significant and the knowledge gap is a key constraint. In terms of time resources, time conflict between agricultural production and classification behaviour is evident [12]. The issues of farmers' participation behaviour are shown in **Table 3**. There are peculiarities in farmers' risk perception. In terms of risk assessment, there are individualised characteristics. In terms of risk response, there is a fatalistic tendency, 65% of farmers in heavily polluted villages believe that pollution is a necessary path to development and that individuals are powerless to change, and this perception inhibits risk response behaviour [13]. The risk-benefit trade-off is out of balance, with farmers perceiving

higher classification costs and lower perceived risk reduction benefits, a cost-benefit inversion that makes it difficult to convert risk perception into classification motivation [14].

Table 3. Problems of farmers’ participation behaviour.

Problems	Specific performance
Farmers’ risk perception is specific	82% of the farmers do not perceive the risk of watershed pollution. 65% of farmers believe that pollution is a necessary part of development and that individuals are powerless to change it
There is an imbalance between risk and benefit trade-offs	Higher categorised costs perceived by farmers. Inverted cost-benefit ratio makes it difficult to transform risk perception into motivation for sorting.

4.3. Rigidity of Policy Implementation and Lack of Adaptability

There are multiple structural contradictions in the policy implementation system, leading to a serious disconnect between governance effectiveness and policy objectives, which is centrally manifested in the alienation of rigidity, failure of synergy and deflation of evaluation, as shown in **Figure 4** below.

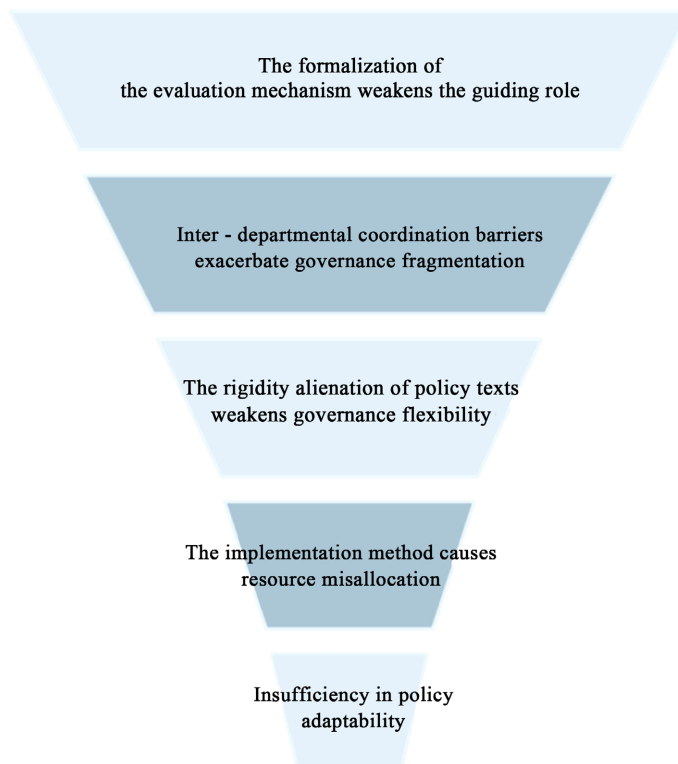


Figure 4. Representation of policy problems.

Alienation of rigidity in policy texts weakens governance flexibility. While 63% of policies at the national level contain flexible expressions such as encouragement and guidance, 47% of local bylaws transform them into rigid provisions such as

prohibitions. This creeping rigidity deprives policies of the elastic space needed by rural societies, as in the case of villages where agricultural subsidies were suspended because farmers failed to classify according to regulations, triggering collective resistance and ultimately forcing policies to be shelved. Excessive reliance on administrative orders has led to policies at the top and countermeasures at the bottom, with farmers coping with inspections through symbolic sorting, and the actual accuracy of sorting being low. The campaign-style governance of the implementation method has resulted in a mismatch of resources. The grass-roots level treats waste separation as a short-term performance project and adopts a “concentrated attack” mode. Heavy investment, light management and care, so that each million yuan of policy input in rural areas to generate the amount of classification is only 1/3 of the urban, a large number of funds deposited in the unused facilities.

Cross-sectoral synergy barriers exacerbate governance fragmentation. Rural waste classification involves agriculture and rural areas, ecological environment, housing and construction and other departments, but the responsibilities of the cross and gaps co-exist, agriculture and rural departments are responsible for the source of classification guidance, but do not have the right to regulate the transport link. The ecological environment department monitors pollution, but is not involved in the development of classification standards. Insufficient policy adaptation. Mature urban policies are directly applied to rural areas, while ignoring the differences in the needs of farmers. Formalisation of assessment mechanisms weakens guidance. Existing assessment focuses on hardware coverage rather than behavioural sustainability, taking the number of waste separation bins and the number of publicity slogans as the core indicators, but ignoring the development of actual classification habits among farmers [15].

4.4. Uneven Facilities and Lagging Technology

Insufficient coverage of sorting facilities. Rural sorting facilities show the distribution characteristics of surplus in the East and shortage in the West [16], and there is a lag in treatment technology, and there is a problem of adaptability between urban technology and rural application of rural household waste treatment technology. In terms of classification technology, the intelligent identification technology commonly used in cities has a recognition accuracy rate of only 58%, far lower than the 89% in cities due to the complexity of rural rubbish composition and insufficient maintenance of facilities [17]. In terms of resourcing technology, the research and development of miniaturised and mobile treatment equipment is insufficient, and the specific technical problems are shown in **Table 4**.

Table 4. Technical issues.

Technical category	Specific data	Indicator value
Classification technology	Rural vs. Urban Intelligent Recognition Accuracy	Rural 58%, urban 89%

Continued

Disposal Technology	North vs South waste disposal cycle (days)	45 days in the North, about 25 days in the South
Resourcing Technology	Percentage of actual treatment to design capacity	37%
Technology Promotion	Percentage of environmentalists with professional background	11%

Lack of digital management. Rural household waste management lacks digital support and forms an empirical governance model. In terms of data collection, manual statistics are still used, and in terms of decision support, there is a lack of data analysis platforms, and policy making still relies on patting the head, such as purchasing treatment equipment according to the original plan despite a 15% drop in rubbish production, resulting in a waste of resources. Interdepartmental data are not interoperable, and the rubbish production data of the agricultural and rural sector and the pollution monitoring data of the ecological environment sector are separated from each other, so that they are unable to form a governance synergy [18].

5. Countermeasures to Improve the Willingness of Farmers to Participate in the Classification and Reduction of Rural Household Waste at Source

5.1. Deepen Theoretical Research and Cognitive Enhancement

Constructing a localised theoretical framework to crack the cognitive fragmentation dilemma. Most of the existing studies directly apply the theory of urban planned behaviour, ignoring the special context of rural acquaintance society, resulting in insufficient theoretical explanatory power. It should be based on the rural social structure, and in the dimension of livelihood value, quantify the actual impact of classification behaviour on farmers' farm costs and health expenditure. In the dimension of policy perception, study the influence mechanism of flexible guidance on the psychology of farm households, such as transforming policy provisions into moral points in village rules and regulations to reduce the resistance to administrative intervention. Designing conversion paths for the elderly group, replacing abstract environmental protection concepts with examples of environmental improvement around them through the mutual aid model.

Innovative cognitive intervention methods to bridge the cognitive gap between groups. We implemented a tiered strategy based on the cognitive characteristics of different groups. For farmers with low educational attainment, we developed visual cognitive tools, together with on-site teaching on composting in the field, to link classification knowledge with agricultural production experience. For young farmers, the use of short videos, live broadcasts and other digital carriers to enhance cognitive impact. Establishing a feedback mechanism, setting up classification effect bulletin boards in villages, and announcing weekly data on the

reduction rate of mosquitoes and flies and the increase in compost production brought about by waste classification, so as to strengthen cognition with empirical results. Integrate classification education into rural compulsory education, and form intergenerational cognitive transmission through the student-family model, so as to fundamentally cultivate sustained cognitive power.

5.2. Improve Farmers' Behavioural Incentive Mechanisms

Material incentives should focus on the actual needs of farmers and design a differentiated exchange mechanism. Spiritual incentives need to be combined with the rural face culture, update the data on the village bulletin board every month, and invite the farmers on the list to participate in the decision-making of village affairs, so as to enhance their sense of social identity. Social incentives rely on the clan network, the classification of performance into the annual review of the clan, with the help of group pressure to strengthen the continuity of behaviour.

The establishment of a closed-loop behavioural feedback system strengthens the long-term effectiveness of incentives. In response to the problem of easy short-term participation and difficult long-term adherence, a dynamic incentive mechanism is designed so that the longer the continuous participation time, the higher the points exchange ratio. Demonstration of rubbish sorting and composting skills on-site can earn participants extra points, forming a virtuous cycle. Provide adaptive support for special groups, and equip elderly farmers with volunteers who come to their homes weekly to assist with sorting and record points, to address their mobility barriers. Implemented for farmers during busy farming periods, allowing temporary storage of recyclables at key points such as sowing and harvesting to avoid giving up participation due to time conflicts. Through precise and dynamic incentive design, farmers can shift from passive coping to active participation.

5.3. Innovative Policy Supply and Implementation

Visualisation of economic value, implementation of the classification weighing and instant redemption model, on-the-spot settlement of recyclables at market price, and redemption of food waste for agricultural coupons by weight [19]. To visualise ecological value, a system of public announcement of data on classification and environmental improvement has been established, whereby changes in water quality and soil indicators in villages are announced every month, and correlation charts between the amount of classified waste and the improvement indicators are displayed. The social value is honoured by the establishment of a classification contribution list, which is ranked according to the amount of classification and displayed in the village cultural hall, forming a social incentive [20]. Long-term value manifestation, the introduction of classification pension points, young classification points accumulated in old age can be exchanged for pension services, multi-dimensional incentives so that farmers perceive the value, promote the willingness to participate in the promotion of the specific innovation policy

supply and implementation of the **Table 5**. optimize the perceptual behavioural control. Construct a three-dimensional support system of knowledge and facilities and time. Accurate supply of classification knowledge, development of classification ability assessment applet, push personalised knowledge packages according to farmers' test results, configuration of small mobile collection points in mountain villages. Classification time cost savings, the implementation of a timed collection mode combined with booking, farmers can make appointments for door-to-door collection by phone. Special support for special groups, equipping elderly and disabled farmers with sorting assistants, providing door-to-door guidance and substitute sorting services, so that farmers' perceptions of perceptual behavioural control are improved.

Table 5. Innovative policy supply and implementation.

Support dimensions	Specific measures
Classification knowledge	Development of classification capacity assessment applet
Layout of facilities	Deployment of small mobile collection points in mountainous villages
Sorting time	Implementing a combination of timed and booked collection modes, whereby farmers can make appointments for door-to-door collection by phone.
Special groups	Equip elderly and disabled farmers with sorting assistants to provide door-to-door guidance and substitute sorting services

Innovative policy supply. Build a flexible policy system. Design guiding and incentive and constraint gradient policy tools. As a guidance tool, classification education should be implemented, combining local theatre and folk stories to disseminate classification knowledge. Incentive tools, innovative classification insurance policy, such as continuous classification for one year farmers can enjoy preferential rates for household property insurance. Restrictive tools, the implementation of rubbish measurement and charging gradient pricing, classification standard households to enjoy preferential rates, not up to the standard households progressive price increases. Hybrid tools, promoting government-purchased services combined with the villagers' autonomy model, introducing social organisations responsible for technical guidance and villagers' committees responsible for daily supervision. This combination of flexible tools avoids the negative effects of a single administrative intervention. Establish a policy precision mechanism to implement differentiated policies for rural heterogeneity. Geographical adaptation, with the eastern region focusing on marketisation combined with digitalisation. For group adaptation, simplified classification combined with door-to-door service for the elderly, and smart classification combined with social sharing for the young and middle-aged.

5.4. Strengthen the Construction of Technology-Enabled Facilities

Build a digital governance platform, and construct a smart management system combining classification over the Internet. On the farmers' side, develop a classification applet, integrating functions such as classification guide, points enquiry and problem feedback. Build a management platform to monitor the status of classification facilities, changes in rubbish production and other data in real time. On the analysis side, use big data to analyse classification behaviour patterns, provide support for precise policymaking, and adjust the collection time to increase the participation rate. At the sharing end, we break through the departmental data barriers and realise the sharing application of classification data with agricultural and environmental protection data, etc. The accuracy of governance decision-making is improved after data sharing. Focusing on group heterogeneity, implementing the classification and empowerment of elderly groups. To popularise knowledge on ageing, a large-print manual on classification was compiled and a dialect version of the classification radio broadcast was recorded to increase the knowledge penetration rate among elderly farmers. Simplified skills training, and one-on-one practical training. Accompanying sorting service, organising volunteers to pair up and assist with sorting on a weekly basis to increase the participation rate of the elderly. Barrier-free facility modification, equipping elderly farmers with lightweight sorting buckets, handrails and other auxiliary facilities, reducing the perceived difficulty of operation for elderly farmers, effectively breaking down the barriers to participation of the elderly group, and narrowing the gap with the middle-aged and young groups.

Strengthening the construction of long-term mechanisms. Construct a mechanism for synergistic development in the East, Central and West, and establish an inter-regional system for resource sharing and capacity building. Build a platform for experience sharing and implement the integration and development of classified talents between the East and the West. Transferring technology centres, building eastern technology transformation bases in the central and western regions, and localising and transforming eastern applicable technologies so as to reduce processing costs in the central and western regions. Mutual fund of capital, set up a regional collaboration fund, and the eastern region injects a certain percentage of its financial income to support the classified projects in the central and western regions. Establish a long-term input and evaluation mechanism to build a sustainable governance guarantee system. Strengthen the financial input mechanism, incorporate rural classification funds into financial budgets at all levels, establish a growth mechanism linked to prices, population and other factors, and improve the maintenance rate of classification facilities. Improve the effect assessment system, formulate assessment norms for rural living rubbish classification, assess the participation rate, classification accuracy rate and other dimensions, and improve the rate of policy adjustment after assessment. Strengthen the feedback mechanism for farmers, establish a classification suggestion box and an online feedback channel to collect opinions and adopt improvement measures.

6. Conclusions

The governance of source classification and reduction of rural household waste is a key issue in rural revitalisation and ecological civilisation construction, and its core contradiction lies in how to effectively transform the willingness of farmers to participate into sustained behaviour. Through systematic analysis of the current situation and problems, the study found that there are multiple structural imbalances in the current governance system, with the rate of waste generation increasing rigidly and the proportion of plastic waste increasing, but most of the treatment still relies on mixed landfill, and the resource utilisation rate is not high, forming a vicious circle. Farmers show a significant paradox of high willingness and low implementation, which stems from both the hardware constraints of insufficient facility coverage and software shortcomings such as cognitive fragmentation and group heterogeneity. The willingness to participate of the highly educated, high-income and youth groups is significantly higher than that of the elderly and low-education groups, and the intergenerational and class differences have widened the governance gulf.

The shortcomings in policy implementation and technology application further exacerbate the governance dilemma. There is a tendency for environmental regulations to be rigid, and local policies have a high level of coercive provisions. High-intensity administrative interventions, although short-term enhancement of coverage, have resulted in insufficient cultivation of endogenous motivation among farmers. At the technological level, the accuracy of smart identification is low in rural areas, and the lack of digital management leads to a high rate of data error. Regional imbalance is also prominent, and the gap between the classification participation rate of farmers in the East and the insufficient rate in the central and western regions reflects the constraint effect of the level of economic development on environmental governance. Cracking the dilemma requires the construction of a synergistic psychological, behavioural and environmental governance framework. Cognitive interventions should be implemented at different levels, including the development of vernacular mnemonics and physical demonstrations for the elderly, and the use of environmental risk visualisation techniques for the youth, to bridge the cognitive gap by linking classification knowledge to agricultural production experience. Behavioural incentives need to be created through a system that combines material and spiritual incentives, and through mechanisms such as point exchange for agricultural materials, so that sorting behaviours can be linked to the immediate interests of farmers. Policy tools need to shift to flexible governance, transforming incentives into innovative forms and balancing regulatory constraints with autonomy. The application of technology should be based on rural realities, promoting adaptive technologies such as voice-prompted bins and solar-powered composting bins, and building cross-sectoral data platforms.

In the long run, the key to modernising governance lies in activating the integration potential of social capital and digital empowerment. At the same time, it is important to bridge the digital divide, develop age-appropriate classification apps, and establish an intergenerational mutual assistance model to ensure the

universality of the technology. In terms of regional synergy, it is necessary to establish a mechanism for experience sharing and technology transfer between the East, the Middle East and the West, so as to narrow the governance gap. The paradigm shift from administrative promotion to endogenous drive should be realised to break the predicament of hot government and cold farmers, and provide sustainable power support for the continuous improvement of rural habitat.

7. Limitations

This study has certain limitations. Firstly, the data are based on self-reported information from farmers, which may be subject to self-report bias and thus affect the accuracy of the results. Secondly, although the survey covers some provinces in the eastern, central, and western regions, the sample still cannot fully represent all rural areas across the country, leading to insufficient regional representativeness. Finally, the study uses cross-sectional data, which fails to capture the dynamic changes in farmers' participation willingness and behaviors, making it difficult to reveal the long-term impact mechanisms.

Author Contributions

Conceptualization, Y.S. and Z.N.; methodology, Y.S., L.H. and C.S.Y.; software, Y.S. and L.H.; validation, Y.S. and L.H.; writing-original draft preparation, L.H. and C.S.Y.; writing-review and editing, Y.S. and L.H., C.S.Y. and Z.N. All authors agreed to the manuscript.

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Data Availability Statement

The datasets generated during and analyzed during the current study is subject to the restrictions under an ongoing project but are available from the corresponding author upon reasonable request.

Ethical Approval

This article does not contain any studies with human participants performed by any of the authors.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Conflicts of Interest

The authors declare no conflicts of interest.

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